THEORY

OF

COLOURS and VISION.

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THEORY

OF

COLOURS and VISION.

By G. PALMER.

LONDON,
Printed for S. LEACROFT, at the *Globe*,
Charing-Croſs.

MDCCLXXVII.

THEORY, &c.

JOHNSON, PALMER.

JOHNSON.

WELL, Mr. Palmer, how do you manage with regard to light?

PALMER.

I obſerve, I analyſe, and I draw conſequences.

JOHNSON.

And for the ſake of your ſyſtem; for I believe you are ſtill fond of it.

PALMER.

More and more.

JOHNSON.

And, probably, you have good reaſons for that.

PALMER.

Very good ones. I will tell you more: I have written a treatiſe upon this ſubject, and have thoughts of publiſhing it.

JOHNSON.

I ſhould be glad to ſee it Sir. Can you ſpare it for a ſhort time ?

PALMER.

With all my heart : and if you chuſe, we will read it together and conſider the experiments.

JOHNSON.

So much the better. We do nothing in this caſe for politeneſs : I hope, Mr. Palmer, you will excuſe my impartiality, and my doubts on the arguments that you are going to ſubmit to my judgement.

PALMER.

Nay, Sir, I would have you reſolutely hold out againſt conviction.

JOHNSON.

So I ſhall, you may depend upon it. I ſhall not, however, oppoſe to you that ridiculous infatuation, which refuſes its aſſent to the moſt evident demonſtrations, and is merely the effect of ſelf-conceit and ſtupidity.

THEORY of COLOURS and VISION.

By *G. Palmer.*

PRINCIPLES.

1. *There is no colour in the light.*

2. *Each ray of light is compounded of three others rays only: one of theſe rays is analogous to the yellow, one to the red, and the other to the blue.*

3. *Theſe rays conſiſt in a different proportion, which they keep exactly, notwithſtanding the decreaſe, or increaſe, of ſtrength of their principal ray.*

4. *The coloured ſuperficies abſorb the rays analagous to the colours of which they ſeem painted, and which are perceived only by the reflection of the other rays.*

5. *A white ſurface, by reflecting all theſe rays, ſhews an abſolute want of colours.*

6. *A ſurface painted of the three colouring principles, in a convenient proportion and denſity, by abſorbing the three rays of light (according to the fourth principle) ſhews an abſolute want of light, or a perfect blackneſs.*

7. *Any one of thoſe three colouring principles is capable of becoming black, without any alteration of its ſubſtance, by abſorbing the rays which are*

are not analagous to it, when its intenſeneſs exceeds the proportion of its own ray.

Of VISION.

PRINCIPLES.

1. *The ſuperficies of the retina is compounded of particles of three different kinds, analagous to the three rays of light; and each of theſe particles is moved by his own ray.*

2. *The complete and uniform motion of theſe particles produces the ſenſation of white: this motion is the moſt tireſome for the eye, and may be ſtrong enough to hurt, or even deſtroy, its organization.*

3. *The abſolute want of motion in theſe particles, whether by the interception of light, or by the aſpect of a black body, produces the ſenſation of darkneſs; and this ſenſation is the perfect quietneſs of the eye.*

4. *The motion of theſe particles by diſcompoſed rays, whether by coloured bodies, or by priſmatic refractions, produces the ſenſation of colours.*

5. *Any uniform motion of theſe particles by rays not diſcompoſed, but only decreaſed, from the white to the black, produces only ſenſations of more or leſs white; but none of colours.*

6. *Theſe particles may be moved by the rays which are not analagous to them, when the intenſeneſs of theſe rays exceeds their proportion.*

6. *It is phyſically impoſſible to determine abſolutely on the degree of white, or black, as that depends upon the organization of the eye. The eagle, which can bear the direct rays of the ſun, muſt ſee grey what appears white to us; and the cat, that is able to perceive objects in the dark, muſt ſee white what appears yet grey to our eyes.*

JOHNSON.

Your three firſt principles are almoſt conformable to thoſe of many other authors; as is likewiſe the greateſt part of your theory on viſion.

PALMER.

I have not the fooliſh idea, that I can reform all that has been done on this matter; but I intend to produce a ſyſtem agreeable to the experiments, and that ſhall defy contradiction; the whole baſis of which ſyſtem is contained in the four laſt principles.

JOHNSON.

It is true, theſe principles are exactly and diametically oppoſite to ours: I am therefore impatient to ſee how you ſupport them by demonſtration.

PALMER.

We ſhall ſee.

I believe that, before we begin a diſſertation, and make experiments, it is expedient, even neceſſary, to examine properly the inſtruments which we make uſe of, as well as their way of acting; for we ſhould not impute to the matter of which we treat, any improper and contradictory qualities, in order to explain ſome particular phænomena, which proceed very often from incidents belonging to the acceſſaries, and not to the thing itſelf.

On this account, we ſhall firſt proceed to the analyſis of the priſm, and accompany it with proper experiments.

When I began this treatiſe, as I had in view to eſtabliſh my work upon a ſolid baſis, I wiſhed to determine the proportion of coloured rays, being perſuaded that the light, being ſo ſteady and exact in its motions and effects, might be ſubmitted to geometrical rules. For this purpoſe, I ſet the compaſs on the priſmatic ſpecus; but I was much ſurpriſed, when in this ſpecus, which I had looked upon as the perfect collection of the primitive colours, I found nothing but an irregular and diffuſe mixture of all theſe colours, from which I could not draw the leaſt conſequence.

EXPERIMENT I.

I brought the ſpecus gradually from the diſtance of fifteen feet, to within two inches of the priſm.

RESULT.

When I brought the ſpecus near to the priſm, I had a long ſquare, of which the ſides parallel to the axis of the priſm were coloured, one with a red and a yellow band; the other ſide, with a blue and a dark-violet one; and the middle of the ſquare, white.

By moving the ſpecus farther, theſe bands grew larger; the yellow came to the blue, and after produced the green, by the mixture of both: and, at a farther diſtance, all the colours were mixed together, without either order or proportion.

Not being able to do any thing with theſe colours, I endeavoured to get them more diſtinct and ſteady, by ſome other way.

Then I perceived very ſoon, that the authors who had worked upon this matter took the coloured rays upon the ſpecus out of the priſm; but none of them minded how they could get in; for, if they had done that, they would have ſeen, that,

1. *An homogeneous ray of light bears no decompoſition in the priſm.*

2. *The light muſt be abſolutely refracted or reflected, in an unequal manner, before it comes into the priſm, to colour the ſpecus.*

3. *Theſe are no more than three different rays, which are yellow, red, and blue.*

4. *The green is produced only by a mixture of the yellow and blue; and this mixture never happens, without the concurrence of two points of refraction.*

5. *The purple never appears but in the ſhadow of the refracting or reflecting body, by the concurrence of red and blue, or by the beginning of a ſecond ſpecus.*

6. *The colour aurora never appears but by the mixture of red and yellow; when, the ſpecus being far removed, thoſe colours get one into the other by their extenſion.*

7. *And laſtly, Whenever a ray of light, before its coming into the priſm, ſhall be refracted, or reflected, by a point only, or a line parallel to the axis of the priſm, there will appear no other colour but yellow, red, and blue.*

JOHNSON.

I underſtand very well: let us ſee the experiment.

PALMER.

EXPERIMENT II.

I cover one ſide of the priſm with a bit of paper, and place the priſm horizontally upon a high houſe, or one of the towers of St. Paul's church, in ſuch a manner that the covered ſide may lie downward, and the other ſides be directed only toward the ſun and the heavens.

RESULT.

If I ſet a ſpecus at the diſtance of ſix inches, I have nothing but the ſhadow of the priſm, coloured on one edge with blue and violet, and with red and yellow upon the other.

If there be any ſpot in the priſm, it appears in the ſhadow coloured on both ſides: and when I remove the ſpecus, then the colours increaſe, and mix as in the firſt experiment.

EXPERIMENT III.

I ſet a priſm horizontally, at the diſtance of one inch, upon a ſheet of paper tied down upon a table, and ſet the eye upon the priſm, at the diſtance of ſix or eight inches: then I move the priſm into the ſame ſituation, to obtain the ſeveral angles of refraction.

RESULT.

Whatever is the colour of the ſheet; if both that and the ſheet be even, I ſee no priſmatic refraction.

EXPERIMENT IV.

Upon this ſheet of paper I draw ſome lines with different colours, and with the ſame as that of the ſheet; only ſtronger, or weaker.

I ſet the priſm as in the preceding experiment.

RESULT.

All theſe coloured lines appear in the priſm with the priſmatic colours, more or leſs perceptible, according to the kind of the colour of the line.

This experiment is one of the moſt curious that can be made with the priſm; for it produces more than two hundred very remarkable effects. I notice this now but ſummarily, that being enough for the preſent: I ſhall give a further account of it in my treatiſe on the Geometrical Proportions of Coloured Rays.

DEMONSTRATION.

The preceding experiments clearly evince, that a homogeneous ray of light bears no decompoſition by going through the priſm; and that it is abſolutely impoſſible that theſe rays ſhould loſe their uniformity by any refraction, or reflection.

It is not very wonderful, that authors are of ſo many different opinions concerning the proportions of colours of the ſpecus, becauſe they take their rays of light by larger or ſmaller holes and priſms: theſe rays being coloured only by the refraction which they underwent on the edges of the holes and priſms, before they arrived at the ſpecus; the colours formed upon the ſpecus were more or leſs diſtant from each other, according to the ſize of the hole, or the priſm.

EXPERIMENT V.

I take a piece of very thin, poliſhed ſilver, ſix inches long, and three lines broad. This I cut, at the edges, in an irregular manner, in order to render them more perceptible through the priſm.

I hang this piece of ſilver in the middle of an open window, in ſuch a manner that it may receive the light of the heavens.

I ſet a priſm parallel to the ſurface of this piece, and equal to it in length, at the diſtance of ſix inches, and in a poſition convenient for obſerving it by the refracted rays.

I place the eye at the inſtance of ten or eight inches from the priſm.

RESULT.

The edge of this piece, neareſt to the priſm, ſeems coloured very diſtinctly with yellow and red; and the other edge, with blue.

The body of the priſm ſeems coloured with purple; and, by the marks which I made on the edges, I perceived very well, that the purple begins only in the ſhadow of the piece of ſilver.

EXPERIMENT VI.

I remove the priſm from this piece to the diſtance of two feet, in a proper direction, looking through it all the time.

RESULT.

As I remove the priſm, the purple becomes in proportion more and more narrow, and at laſt diſappears; the blue comes cloſe to the red, and gives it a little tint of crimſon, and a very ſmall tint of green to the yellow.

If I ſtill remove the priſm farther, the colours decreaſe, and at laſt vaniſh, without any farther mixture.

EXPERIMENT VII.

I ſet the priſm as in the 5th experiment, and bring it gradually nearer to the piece, till within the diſtance of ſix lines.

RESULT.

In proportion as I move the priſm, the purple diſappears; the other colours become narrow; and when it is at the diſtance of ſix lines, I ſee nothing but the body of the piece of ſilver appearing black, with a very ſmall coloured ray on each edge, yellow and red on the firſt, and blue upon the other.

EXPERIMENT VIII.

Inſtead of this piece of ſilver, I ſet upon one of the window frames a brown or black hair, extended, to keep it right.

I ſet the priſm parallel to it, at the diſtance of ſix lines, and the eye at three or four inches.

RESULT.

I ſee a band about one line and a half broad, conſiſting of three coloured rays, and very diſtinct in this order, yellow, red, and blue.

If I remove the priſm farther, the colours decreaſe, and diſappear, without producing the leaſt ſhade of green, purple, or aurora.

DEMONSTRATION.

Theſe four laſt experiments leave no doubt as to the non-exiſtence of the purple, green, and aurora, as primary colours,---by ſhowing that they never appear but accidentally, and by the mixture of the three others.

Theſe experiments are ſo much more deciſive, as they ſhow the decompounded rays in their greateſt degree of ſimplicity, (I mean, which can be perceived;) and, beſides, they are free from any variation.

We ſhall now proceed to produce theſe colours in a different manner.

EXPERIMENT IX.

I introduce a ray of the ſun into a dark room, (by the means of a tub adapted to the ſhutter, and a looking-glaſs,) in the manner uſually practiſed.

On the inſide end of the tub I ſet a piece of very thin ſilver, faſtened upon a paſte-board frame, ſo that the whole may exactly cloſe the tub.

With a pen-knife I cut a ſmall ſlit, ſix lines long, in the middle of the piece of ſilver, and as narrow as poſſible, without the light being intercepted in any part of it.

Suffering a ray of the ſun to paſs through this ſlit, I ſet a priſm at the diſtance of one inch, in a convenient poſition to refract the ray.

To the other ſide I apply a ſpecus, at the diſtance of ſix inches.

RESULT.

The ſpecus is about ſix lines broad, and very diſtinctly coloured with red, yellow, and blue, without any white; and on the edge of the blue, in the beginning of the ſhadow, there is a fillet of red purple, very diſtinct and dark.

In the yellow and the red there is a very little tint of the blue, not ſufficient to make any alteration in the green or purple.

EXPERIMENT X.

I remove the ſpecus to the diſtance of three feet.

As I move the ſpecus farther, the colours get more extenſion, and mix themſelves one in the other; and at this diſtance of three feet, the ſpecus is coloured diſtinctly with red, aurora, yellow, green, blue, and purple, in proportions different from thoſe in the Newtonian ſpecus; becauſe there is no white to be filled up, before the yellow comes cloſe to the blue.

EXPLANATION.

Theſe experiments, confirming my principles, ſhew, that the large white ray of light, of the Newtonian priſm, has no colour of itſelf, but is mixed with the coloured rays.

JOHNSON.

What does it do then?

PALMER.

I believe it has led all the natural philoſophers into an error, by giving to the other coloured rays ſuch a refrangible and reflectible quality, as that they bear no further decompoſition, whether in a ſecond priſm, or upon the coloured ſuperficies.

JOHNSON.

I know, all authors are agreed in this opinion.

PALMER.

And they are in the right; for I could make very little decompoſitions of the ſeparated rays of the Newtonian ſpecus: but I can eaſily do it with the ſpecus of the preceding experiment, as you ſhall ſee.

EXPERIMENT XI.

Every thing diſpoſed as the experiments IX. and X. I ſet a large piece of paſteboard

board at the diſtance of five feet from the priſm.

I make, in this board, a hole of three lines diameter, in order to tranſmit each ray ſeparately.

I ſet a priſm behind the paſteboard, at the diſtance of four inches, in a convenient poſition to receive, and refract, the tranſmitted ray; and then I look in the priſm.

RESULT.

I ſee the edges of the hole, coloured with the priſmatic colours, more or leſs affected by the colour of the tranſmitted ray.

If, inſtead of the eye, I apply a white paper, the ſpecus will be coloured, but faintly, in the ſame manner.

EXPERIMENT XII.

I ſet behind the hole a lens, whoſe focus is about three inches: I receive this focus upon a priſm, and place a ſpecus at the diſtance of eight or ten inches.

RESULT.

The ſpecus is then coloured more diſtinctly.

OBSERVATION.

Theſe experiments produce very curious effects, of which I can at preſent give no particular account, for they are much too numerous to be explained in ſuch a ſuccinct diſcuſſion.

I ſhall endeavour to publiſh them as ſoon as poſſible, and when the ſeaſon ſhall be more convenient for the experiments depending on the ſun's rays.

APPLICATION.

Although, by theſe reſults, I am evidently right in believing that the white light of the Newtonian priſm is the true cauſe of the non-decompoſition of the coloured rays; I will not pronounce abſolutely upon this matter, for I have not made experiments enough to be perfectly convinced; and it is a rule with me, not to adduce conjectural proofs till I ſhall have exhauſted my geometrical and philoſophical ones.

JOHNSON.

I ſuppoſe you will make drawings of the apparatus uſed in all theſe experiments, in order, when you print, to illuſtrate them with engraved figures.

PALMER.

Not yet; for I deſign the preſent work only for natural philoſophers, and ſuch other perſons as are acquainted with the method of uſing the priſm; wherefore I decline mentioning many other experiments, though as ſhort and eaſy as thoſe already recited: nor ſhould I even introduce this ſummary diſſertation on the priſm into my preſent-intended treatiſe, but for the neceſſity of giving demonſtrative proof, that light conſiſts of no more than three primary coloured rays.

JOHNSON.

I am convinced of that; but many people will obſerve, that if we contemplate the rainbow, we ſhall perceive therein ſeven colours.

PALMER.

We ſhall ſee more than ſixty, as in the common ſpecus, and in mine, when they are removed far enough from the priſm.

JOHNSON.

But nature, you know, never errs.

PALMER.

True: and nature, you will likewiſe obſerve, never produces bodies but ſuch as are compounded; never deſcribes any lines but curved ones. Yet, ſhall we on this ground conclude, that the ſhorteſt way from one point to another is not by a right line? or that a vegetable, or mineral, from which we can eaſily extract different ſubſtances, is merely a ſimple body?

JOHNSON.

By no means.

PALMER.

I venture to affirm, that we never ſaw the primary colours in an abſolute degree of purity; for, as we have in no caſe, either from nature, or by art, been able to reduce any body to a ſtate abſolutely ſimple, this muſt be imputed either to the inſufficiency of the operations we have had recourſe to, or elſe to the qualities of bodies, in themſelves indiviſible, except to a certain degree.

JOHNSON.

But have you not told me ſometimes, that you and other chemiſts have divided bodies into their conſtituent particles; and that theſe particles are not capable of any further decompoſition?

PALMER.

Yes, that the means of ſuch further decompoſition has not yet come within the reach of human genius: but how do we know that this point will not be effected by ſome future diſcovery?

Newton, Deſcartes, and their followers, concluded that the priſmatic rays were indiviſible; and this has been admitted as a rule for many years: notwithſtanding which, the fact is, as you ſee, that I decompound them.

JOHNSON.

And, probably, you conſider this decompoſition as the laſt of which they are capable?

PALMER.

Not I, indeed, Sir. In my youth, perhaps, infatuated by the ſucceſs of my experiments, I might have preſumed to ſet limits to priſmatic diſcoveries, and, with the moſt ridiculous pride, have defied all the philoſophers in the world. But a ſeries of years, ſpent in laborious enquiries, ſufficiently convinces me, that in the ſtudy of the abſtract ſciences we run a career, of which the boundary is unknown to us: and when chance, or our own reaſoning faculties, bring us a little farther than any of our predeceſſors have gone; then either egotiſm perſuades us that we have attained the deſired end, or elſe reaſon ſhews us the impoſſibility of attaining it.

Let us now return to our firſt principles, having loſt ſight of them during this digreſſion. We will read them again, according to the order of the experiments.

JOHNSON.

That will render them more intelligible.

PALMER.

PRINCIPLE I.

There is no colour in the light.

JOHNSON.

You need no experiment to illuſtrate this principle; for moſt philoſophers are agreed, that colours are perceived by the ſoul, merely by the ſenſation of the retina, affected by the touch of the rays; and not by a coloured fluid, or any emanation from a coloured body.

PALMER.

PRINCIPLE II.

Each ray of light is compounded of three others rays only: one of theſe rays is analogous to the yellow, one to the red, and the other to the blue.

I believe this principle is ſufficiently demonſtrated by the experiments that we have made with the priſm; and it is, moreover, confirmed in the ſequel of my treatiſe.

PRINCIPLE III.

Theſe rays conſiſt in a different proportion, which they keep exactly, notwithſtanding the decreaſe, or increaſe, of ſtrength of their principal ray.

JOHNSON.

Nor does this principle need any demonſtration; for every body knows, that a white ſurface, brought gradually from the fulleſt light to the deepeſt darkneſs, never appears of any ſenſible colour.

PALMER.

PRINCIPLE IV.

The coloured ſuperficies abſorb the rays analagous to the colours of which they ſeem painted, and which are perceived only by the reflection of the other rays.

PRINCIPLE V.

A white ſurface, by reflecting all theſe rays, ſhews an abſolute want of colours.

PRINCIPLE VI.

A ſurface painted of the three colouring principles, in a convenient proportion and denſity, by abſorbing the three rays of light (according to the fourth principle) ſhews an abſolute want of light, or a perfect blackneſs.

PRINCIPLE VII.

Any one of thoſe three colouring principles is capable of becoming black, without any alteration of its ſubſtance, by abſorbing the rays which are not analagous to it, when its intenſeneſs exceeds the proportion of its own ray.

JOHNSON.

You may depend upon it, I ſhall grant you nothing, with reſpect to theſe principles, that I have the leaſt chance of refuting.

PALMER.

I applaud your reſolution.

EXPERIMENT XII.

Taking a piece of white paſte-board, two inches long, and one broad, I divide it into eight parts; one I leave white, and the other painted as you ſee; one yellow, one red, one blue, one aurora, one green, one purple, and one black. All theſe colours are as ſtrong as they can be without becoming dark. I call this piece of paſte-board, ſo painted, my repoſitory of colours.

I introduce a ray of light into a dark room, as in the ninth experiment.

I ſet, on the end of the tub, a yellow glaſs, as ſtrong and as pure as poſſible; and at the diſtance of eight or ten inches I ſet my repoſitory.

RESULTS.

The White appears	Yellow
Yellow	Yellow
Red	Aurora
Blue	Green
Aurora	Aurora, yellowiſh

The Green appears	Green, yellowiſh
Purple	Black
Black	Black.

EXPERIMENT XIV.

I place a red glaſs in the room of the yellow, and leave the repoſitory as formerly.

RESULTS.

The White appears	Red
Yellow	Aurora
Red	Red
Blue	Purple
Aurora	Aurora, reddiſh
Green	Black
Purple	Purple, reddiſh
Black	Black

EXPERIMENT XV.

I apply a blue glaſs.

RESULTS.

The White appears	Blue
Yellow	Green
Red	Purple
Blue	Blue
Aurora	Deep grey, almoſt black
Green	Green, bluiſh
Purple	Purple, bluiſh
Black	Black

APPLICATION.

If, according to the common ſyſtem, the coloured ſuperficies reflected each the ray of its own colour, and abſorbed the others; and the coloured glaſſes tranſmitted only the rays of their own colours reſpectively, and reflected the others; in this caſe, I ſay, when I caſt a red ray upon a blue body, the glaſs tranſmitting only the red ray, and the blue abſorbing this red ray, I ought to ſee it black; as alſo of the yellow: whereas I ſee the red ray purple, even to the very tint of a purple compounded of common red and blue; and in the ſame way the yellow appears aurora.

But if, according to my fourth principle, the coloured ſuperficies abſorbs the ray analogous to its colour, and reflects the others; the coloured glaſs would deſtroy but one ray, and tranſmit the two others; which is the fact.

In like manner a red glaſs tranſmits the blue and the yellow.

And when I ſet the red light of this glaſs upon a blue ſurface, this ſurface, abſorbing the blue and reflecting the yellow only, produces in my eye the ſenſation of purple, by the repoſe of the particles of the retina analogous to the blue and the red rays.

If, by abſorbing the yellow too, I produce no motion of theſe particles, I ſhall ſee black.

And this happens when I ſet this red ray upon a green body; becauſe the glaſs having deſtroyed one of the three rays, and the body having abſorbed the other two, it is phyſically impoſſible that I ſhould receive any light.

Examine theſe three experiments in every poſſible way, and even diverſify them by the uſe of glaſſes coloured green, aurora, or violet, or by looking at the repoſitory through coloured glaſſes; they ſhall ſtill be found always conformable to the fourth principle, always inexplicable by the common ſyſtem.

For as often as any one of the three primary colours ſhall be lighted by a ray of another primary colour, the reſult will be a colour very diſtinctly mixed.

And as often as two primary colours united together, ſhall be lighted by a ray of the third colour, or a ſingle primary colour ſhall be lighted by a ray compounded of the two others, the reſult will be black or grey.

JOHNSON.

Why grey?

PALMER.

Becauſe, as will appear in the ſequel of theſe experiments, there is always a certain quantity of white light not decompounded, whether by the weakneſs of the colours that we make uſe of, or by that of glaſſes; and this white light, mixed with the black of the operation, conſtitutes the grey.

It happens very often, that one or two of the primary colours appear with the grey, and ſeem only a deep blue, or red, purple, &c. a circumſtance tending to lead the obſerver into an error.

It is to be conſidered, that ſuch appearance happens only when the colours are not in geometrical proportions, as I ſhall prove in the ſecond part of my Treatiſe; and then the colours, whoſe intenſeneſs exceeds the proportion of the others, appear, by the white light, in the grey only, and never in the black.

EXPERIMENT XVI.

I re-unite the rays of the three aforeſaid glaſſes ſeparately, in a focus, by way of a lens.

RESULT.

Although the rays are contained in a ſmaller ſpace, the colour does not increaſe; and when the focus is as narrow as poſſible, I ſee nothing but a point of very ſtrong light very faintly coloured.

This experiment may be made with the ſeparated rays of the ſpecus, or with coloured lights; as the yellow light of a common candle, or the blue light of burning verdegris; and the ſame effects will be produced.

APPLICATION.

If the coloured ray ſhould be the proper ray of the colour which appears, the intenſeneſs of this colour would increaſe with its own; and the focus would be exceſſively coloured, as being a ſtrong re-union of the coloured points.

But, as the colour of this ray is ſeen by its abſence, and by the repoſe of the analogous particles of the retina, it is certain, that, although I increaſe the intenſeneſs of the ray which appears by being deficient, I do not thereby render it more deficient; nor can I ſee its colour ſtronger.

Beſides, when theſe rays have, by their intenſeneſs, acquired a great degree of ſtrength, they move the particles analogous to the abſent ray, (as I ſaid in the 6th Principle on Viſion,) and deſtroy a part of their repoſe in a manner very tireſome to the eye; for it bears rather a white focus of the ſame denſity, although ſtronger than many of the before-mentioned ones.

EXPERIMENT XVII.

I dye a piece of white woollen cloth, of a deep blue, with indigo.

EXPERIMENT XVIII.

I take a piece of this blue cloth, and a piece of white, and dye them both, in the manner commonly practiſed, with cochineal.

RESULT.

The blue cloth becomes a deep purple; and the white, a crimſon red.

EXPERIMENT XIX.

I take a piece of the purple cloth, and another piece of white.

I give them both a yellow dying in woad.

RESULT.

The purple cloth becomes black; and the white, yellow.

APPLICATION.

This experiment, although implied in the former ones, yet being rendered more demonſtrative in this way, muſt decide between the old ſyſtem and mine.

If, according to the old ſyſtem, each of theſe colours has reflected its own ray, we muſt abſolutely agree,

That by abundance of light, we have produced darkneſs.

But if, according to my principles, each colouring particle abſorbs its own ray, then we may ſay, *That having ſucceſſively abſorbed the three rays which compoſe the light, we have produced the darkneſs.*

EXPERIMENT XX.

I dip this piece of black cloth in hot vinegar.

RESULT.

This acid deſtroying only the yellow, the cloth becomes purple again.

EXPERIMENT XXI.

I dip this purple cloth in a warm mixture of water and oleum vitrioli.

RESULT.

This acid deſtroying only the red of the cochineal, the cloth becomes blue again.

APPLICATION.

Theſe experiments, the reverſe of the foregoing, ſhew, that by the deſtruction of the colouring particles, we produce the white; and beſides, that theſe colours were really exiſting in the black; and that this black was not produced by a chemical alteration of their ſubſtance.

JOHNSON.

But is is not poſſible that theſe coloured particles, being applied one upon the other, may loſe their reflecting quality?

PALMER.

In the firſt place (as I ſhall prove in my Chemical Treatiſe upon the Art of Dying,) the coloured particles very ſeldom, perhaps never, can be applied one upon the other.

But, granting this to be the caſe, why, when I ſet but two of theſe colours upon the cloth, do they not prejudice one another? Beſides, what becomes of the white points which remain when the cloth is purple? for you know we cannot ſee a coloured point, if there be no white point near it. They ought then to be dyed in yellow, in order to make them appear yellow.

JOHNSON.

According to your principle, pray, what becomes of them?

PALMER.

The white points left by the blue, and which reflect only the red and yellow, are half covered by the red in the ſecond dying; and what remains of them being almoſt entirely covered by the yellow, in the third dying, the cloth reflects but very little light; and it is on account of this remaining light that we diſcern the predominant colour of the black, when we ſay a bluiſh black, a rediſh black, &c.

JOHNSON.

The black is commonly dyed with a dye already black.

PALMER.

Becauſe it is more eaſy, and a great deal cheaper this way.

JOHNSON.

I underſtand very well all that you ſaid, and I begin to believe it; but there are yet many things to be explained.

As for example, the re-union of the coloured rays of the priſmatic ſpecus produces the white.

If, as you ſay, each colour is perceived by the want of its analogous ray, this union of defects ought to produce a general deficiency.

PALMER.

Certainly; but each one being ſeen by the preſence of the other rays, this union of preſence makes a general preſence, which deſtroys the general defect; and when, by the interception of one of theſe rays, I deſtroy the uniformity of their action upon the retina, I produce a coloured ſenſation.

And that is the reaſon why a mixed colour, formed by two coloured rays, is ſomething weaker than each ray is ſeparately; as we ſhall ſee with the three coloured glaſſes of the Experiments XIII. XIV. XV.

EXPERIMENT XXII.

I ſet each of theſe glaſſes upon a particular tub, very near one another.

I open the red and the blue, and receive their light upon a white paſte-board, at a diſtance ſufficient to have them mixed.

RESULT.

I have a purple ſenſibly lighter than the red, or the blue, ſeparately.

EXPLANATION.

The blue glaſs tranſmits a red ray, and a yellow one.

The red glaſs tranſmits a blue ray, and a yellow one.

And ſo the light reflected by the paſte-board conſiſts of four rays, one blue, one red, and two yellow.

One of the yellow rays, combined with the blue and the red ones, makes white; the exceeding yellow ray cauſes the ſenſation of purple; and this purple is the lighter for being united to a larger quantity of white light.

EXPERIMENT XXIII.

I give to this exceeding yellow ray another blue, and another red one, by opening the yellow glaſs.

RESULT.

This produces the ſenſation of white light.

APPLICATION.

Although this light appears white, it is leſs than a pure light, which ſhould have been tranſmitted by white glaſſes; becauſe each glaſs having intercepted one ray, and tranſmitted two, this light conſiſts of two thirds of light rays, and one third of ſhadow.

The ſame thing happens in the re-union of priſmatic rays with a lens. This focus is leſs white than the focus of the ſame ray before its refraction in the priſm.

This is not effected by the light being decompounded, and compounded again; but becauſe the priſm reflects a large quantity of light at its ſurface; and the want of this light, in the rays tranſmitted to the ſpecus, is the cauſe of this difference in the focus.

EXPERIMENT XXIV.

I introduce a ray of light into a tub; upon this tub I ſet a blue glaſs; and upon this blue glaſs, a red one.

RESULT.

The paſte-board is coloured with a purple, deeper than the blue, or the red, was ſeparately.

EXPERIMENT XXV.

Upon theſe two glaſſes I ſet a yellow one.

RESULT.

If the glaſſes are well and ſtrongly coloured, I have no more light.

But, if they are not well coloured, or in a convenient degree of ſtrength, I have but a very faint light, weakly coloured with one or two of the exceeding colours of the glaſſes.

APPLICATION.

The purple of Experiment XXIV. muſt certainly be deeper, becauſe the blue glaſs has tranſmitted two rays out of three; and the red glaſs having deſtroyed one of theſe two, there remained but one, by which the purple is perceived; and this being deſtroyed by the laſt glaſs, there remains none to be ſeen.

JOHNSON.

An obſervation concerning thoſe coloured glaſſes naturally ariſes from your remark, that they tranſmit two rays, and abſorb one.

If it be ſo, when I ſet one of theſe glaſſes upon a ſheet of paper, and look over it, it ought to appear of a colour quite different from what it does when I look through it; nevertheleſs it appears of the ſame colour, though a great deal darker.

PALMER.

According to authors who have written on the ſubject, it ought to be ſo; for many of them have ſaid, a red glaſs *tranſmits* the red ray, and *reflects* the blue and the yellow ones; from which it ſhould follow, that a red glaſs ſhould look green; a blue one, aurora; a yellow one, purple, &c. notwithſtanding which it never does ſo.

But, according to my opinion, it *abſorbs and deſtroys* one ray, and tranſmits two.

Upon which account, when you look through it, you have a ray of ſtrong light, coloured by the want of the abſorbed ray.

When you look over it, then you receive but very little reflected light, becauſe it is a tranſparent body: and this light, even wanting the deſtroyed ray, gives a very dark ſenſation of this colour.

If you ſet this glaſs upon a white body, the ſenſation will be ſtronger; many of the tranſmitted rays being reflected by the white ſurface, and returned to the eye through the glaſs.

The variations in the intenſeneſs of colour of theſe glaſſes, ſo looked over, depend much, too, upon the angles deſcribed upon the ſurface of the glaſſes by the light, or by the viſual rays.

JOHNSON.

Neverthele ſs we have the experiment of the gold leaf, which reflects the yellow rays, and tranſmits the green ones.

PALMER.

When the authors of the common ſyſtem have urged this experiment, concerning which they were unanimous in their opinion, they had no reaſon to conſider it as dubious; and they admitted it without any further examination, as they have done many others.

This gold leaf is an opaque and porous body; and to have the colour paſs through it, we muſt reduce it mechanically to its utmoſt degree of thinneſs; and then it will be two thouſand four hundred times thinner than a green glaſs, which ſhould tranſmit the ſame quantity of light.

May we then really believe, that we made a tranſparent body of an opaque one?

We have made a ſieve, the holes of which ſuffer the light to paſs through.

This ſieve being then lighted, if we look over, the ſolid parts of it will appear yellow, as they uſed to do.

But the tranſmitted rays, which paſs through the holes, undergo at once a reflection, a refraction, and a decreaſe; and as the refraction in blue is the moſt apparent in a decreaſed light, the refracted rays, mixed with the reflected ones by the edges of the holes, produce the green.

Although this experiment is of no conſequence in the preſent diſſertation, I made a particular analyſis of it, in order to ſhow how exact we muſt be in our operations; and how well acquainted with the materials that we make uſe of, as well as of the mechaniſm of their action.

We ſhall end this diſſertation with an experiment of this kind, which, for want of examination, has been admitted as a rule in optics.

EXPERIMENT XXVI.

I take three crayons of paſtel; a blue, a red, and a yellow one; all three in the ſame degree of ſhade, or as nearly ſo as the eye can judge, and of a good ſtrength of colour. I reduce them ſeparately to a ſmall powder.

I take nine parts of the blue powder, and eight parts of the red, and mix them exactly.

RESULT.

The mixture is purple.

EXPERIMENT XXVII.

I add to this mixture ſeven parts of yellow.

RESULT.

The mixture appears grey.

JOHNSON.

And why not black, as the piece of cloth did?

PALMER.

Becauſe every one of theſe colours brings its white particles, by which it is ſeen; and, as they cannot be deſtroyed, they produce the grey, by reflecting to the eye a light uniformly altered by the proportionate mixture of the three colouring principles.

When the founders and followers of the old ſyſtem intended to prove the compoſition of the white by the re-union of the primitive colours, they mixed together cinnabar, verdegris, purple, mountain blue, and other light colours. This mixture produces a weak grey; but the cauſe of it being abſolutely inexplicable on their principles, and as they were obliged to adapt this experiment to their ſyſtem, they removed themſelves to the diſtance of eighteen feet, to look at this grey powder; and being not able to diſtinguiſh it there from a white paper, they concluded that they had produced the white by this means.

JOHNSON.

But, pray, were they in the wrong, when they had ſuch evidence on their ſide?

PALMER.

I do not mean to ſay, that they were in the wrong in ſeeing it white, for I ſee it the ſame; nor do I believe that this experiment was agreeable to their ſyſtem.

But ſince I cannot uſe myſelf to ſee white what is black, without knowing the cauſe of it, I chuſe to be more inquiſitive.

EXPERIMENT XXVIII.

I compound a grey with many colours, as is preſcribed by the ſeveral authors.

I compound a grey, of the ſame ſhade, with black and white powder.

I take a ſheet of muſical paper, and a ſheet of white paper.

I lay my grey powder upon two paſteboards, and ſet them on the floor with the two ſheets of paper, in ſuch a poſition that they may be lighted by the window, under an angle of twenty to thirty degrees.

I go on the other ſide, oppoſite to the window, to the diſtance of eighteen feet from the ſheets.

RE-

RESULT.

I can hardly diſtinguiſh the three coloured leaves from the white one; and any body elſe, who has not ſeen them nearer, cannot do it at all.

EXPERIMENT XXIX.

I ſet the ſheets nearer to the window, in ſuch a manner that they may be lighted under an angle of more than ſixty degrees. I go to the ſame diſtance of eighteen feet.

RESULT.

I diſtinguiſh very well the three coloured ſheets, and every body elſe does the ſame.

EXPERIMENT XXX.

I ſet the four ſheets at the diſtance of eighteen feet from the window, and come near to the window to look at them.

RESULT.

I diſtinguiſh them better again.

EXPLANATION.

When I light the ſheets under an angle of about thirty degrees, and ſee them under an angle of ſixteen degrees in an oppoſite way, as in Experiment XXVIII. the rays brought to my eye conſiſt of a great deal of white light, refracted by the ſuperficies, and which bear no decompoſition; and of a ſmall quantity of reflected rays, which do bear a decompoſition on the coloured ſuperficies. This decompoſition being but an uniform alteration, and very weak, cannot be perceived by the naked eye at ſuch a diſtance.

If this decompoſition is made by a ſurface coloured with two, or only one, of the primitive colours, then the alteration, being not uniform, is more perceptible; nevertheleſs the colour muſt be pretty ſtrong, to give a coloured ſenſation at this diſtance; otherwiſe it appears white.

When in Experiment XXIX. I light the ſheets under a greater angle, I decreaſe in my eye the quantity of the refracted rays, and I increaſe this of the reflected ones; which makes the ſenſation more diſtinct.

And when in Experiment XXX. I ſee my ſheets only by the reflected rays, the ſenſation is more perceptible yet.

You ſee, now, that the authors of this experiment have aſcribed to the matter which they treated, what was only the product of their way of acting. Natural philoſophy is full of ſuch experiments, and this matter cannot be otherwiſe in ſo conjectural a ſcience.

Let us now put an end to our diſcuſſion. In our next we ſhall treat of the Seventh

Principle, becauſe this of itſelf will furniſh matter ſufficient, and is well worthy a particular Treatiſe.

There we ſhall examine the geometrical proportions of the three primitive colours, as well in the priſmatic ſpecus, as in the coloured ſuperficies:

The analogy of colouring particles with the compounding rays of light, and their action:

Their abſolute intenſeneſs, and their relative intenſeneſs:

Their increaſe and decreaſe, &c.

JOHNSON.

This is all very well; but I have ſomething to remark. If your ſyſtem be juſt, and well demonſtrated, then we muſt believe that the other authors were out of their ſenſes, and conſequently we muſt deſpiſe them.

PALMER.

I am very ſorry to find you in ſuch an erroneous way of thinking, which unfortunately is too general a caſe.

Was he who firſt ventured to croſs the ſeas, although he might often deviate from the right track, was he, I ſay, in nothing ſuperior to any of his followers?

So theſe ſuperior geniuſes have opened to us the roads in which we now tread, and furniſhed us with the means of travelling over them. Perhaps, but for their ſagacity, we ſhould ſtill be creeping on in darkneſs and obſcurity: But, perſuaded by egotiſm that we ſhould have made theſe diſcoveries ourſelves, we inſult their errors, and deny them the grateful praiſe we owe to their memory.

I do not, however, mean to ſay, that we ought to look upon the writings of theſe authors as invariable rules, or that we ſhould have ſuch reſpect for their ſyſtems as never to ſpeak againſt them; but, as theſe contradictions cannot deſtroy the Creator's merit, whilſt we reject their opinions, let us leave them this glorious title; and let their names, tranſmitted to poſterity, with all the veneration which they deſerved, be for ever the baſis of thoſe columns, which all liberal artiſts will chearfully adorn with their trophies.

FINIS.